CHAPTER 19

ASIA

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19.1 INDIA

Established in 1965 as the Pre-Investment Survey of Forest Resources and reorganized 1981, the Forest Survey of India (FSI) is entrusted with the responsibility of surveying forest resources over the entire country. It has its central organization in Dehradun and zonal offices in Bangalore (southern), Kolkata (eastern), Nagpur (central) and Shimla (northern).

The primary mandate of the FSI is:

- to prepare a State of Forest Report biennially, providing an up-to-date assessment of the forest cover and monitoring changes in this,
- to undertake a Forest Inventory, an Assessment of Trees Outside Forest and an Assessment of Wood Consumption,
- to prepare thematic maps to a scale of 1:50 000 using aerial photographs,
- to function as a nodal agency for the collection, compilation, storage and dissemination of spatial data on forest resources,
- to conduct training of forestry personnel in the application of technologies related to resource surveying, remote sensing, GIS, etc.
- to strengthen its own research and development infrastructure and to conduct research into applied forest survey techniques,
- to support State/UT Forest departments for forest resources surveying, mapping and inventory purposes, and
- to undertake special studies/consultancies related to forestry and to create customised training courses for SFD's and other organisations on a project basis.

A. Kangas and M. Maltamo (eds.), Forest Inventory – Methodology and Applications, 309–324.

Its current activities include:

- a Forest Cover Assessment
- a Forest Field Inventory
- Forest Inventory Data Processing and Analysis
- an assessment of Trees Outside Forests (TOF)
- an assessment of the Consumption and Utilisation of Wood and NWFP in the Household Sector
- Training and Extension

These current activities also include special studies and consultancy work, such as support for the State Forest Departments in connection with their forest inventories and GIS capacity building. The current field inventory data also allow the assessment of non-wood forest products (NWFPs), the carbon stock contained in the forest biomass and forest soil and biodiversity indices.

IRS 1C / 1D LISS images are used for forest cover mapping. The whole of India can be covered with 342 LISS images, with a rate of overlap between adjacent scenes of about 20%. The FSI acquires the system-corrected images from National Remote Sensing Agency (NRSA). The most suitable image acquisition date in India is after the rainy season, i.e. from October to January, which is also the best time for the observation of deciduous forests. Tests have also been made with the use of IRS PAN imagery together with LISS data, in order to improve the present forest cover mapping and the estimation of the numbers of trees outside the forest area.

19.1.1 Forest cover mapping

Biannual forest cover mapping has been one of the major activities of the FSI central office. Earlier, Landsat MSS and TM data were used as the primary sources, but Indian Remote Sensing satellite images have been adopted since the fifth mapping exercise. The methodology has been developed from the level of visual interpretation to complete digital processing lasting the course of the latest inventories (1999-2001). All the new maps in the 2001 forest cover mapping were produced by digital methods.

For digital interpretation, satellite data is procured in digital form from the National Remote Sensing Agency in Hyderabad and basic radiometric and stretch corrections are applied to remove radiometric defects and improve the visual impact of the False Colour Composite. Geometric rectification of the data is carried out by reference to scanned topographic maps. No digital elevation model is available.

The forest cover is described in terms of the following classes:

1. Dense forest (forest cover/canopy density > 40%)
2. Open forest (forest/canopy density 10-40%)
3. Mangrove (special areas)
4. Scrub (poor growth and forest cover/canopy density < 10%)
5. Non-forest

The data classification procedure is the following:

1. The forest areas in the scene are classified digitally. Topographic maps,

vegetation maps from the previous mapping cycle and field control for unclear locations are used in this classification.
2. The forest cover is classified in terms of density using NDVI transformation. The threshold values for the density classes are determined for the NDVI image and these areas are used directly as forest cover estimates. Shadow areas in the scenes are treated separately.
3. Mangroves are interpreted separately due to their special reflectance, texture and location characteristics.
4. The classified scenes are mosaicked and reports by state and district are extracted using boundary layers.

Topographic maps to scales of 1:1 million and 1:250 000 were used earlier as primary reference data, but nowadays 1:50 000 topographic maps are used for digital image processing. The entire country is covered by 363 map sheets on a scale of 1:250 000 or 5200 sheets on a scale of 1:50 000.

19.1.2 Forest inventory

National Forest Inventory has been one of the major activities of the FSI and the Pre-Investment Survey of Forest Resources. The old inventory system was based on two-stage random sampling with post-stratification. Prior to 1982, stratification was based on aerial photographs, which were used to derive thematic maps, but from that year onwards each topographic map (1:50 000) has been divided into a grid of 36 elements covering 2 ½' × 2 ½' of latitude and longitude, with two sample points marked in each grid square at random. The inventory data are collected from a square plot of 0.1 ha laid out on the ground at each of these sample points. The FSI covered an area of about 680 000 km^2 and produced 130 inventory reports between 1965-1995.

Between 1996 and 2001 the inventory activities of FSI were concentrated on the assessment of "trees outside the forest", and traditional forest inventory work was suspended. Since 80% of the country's forest area had been inventoried by 1995-1996, it was felt at that juncture that it was important to assess trees outside the forest, as these had traditionally not been inventoried at all and little quantitative information existed on them. TOF also provide support for the rural economy and for food security.

The policy changed in 2001-2002, and work began on establishing a new methodology for integrated forest resource assessment. The FSI proposed that it should supplement the usual field inventory with measurements of several other parameters in order to obtain a comprehensive assessment of forest resources inside and outside forest areas at the national level. Additional data will now be collected during the field inventory stage to assess regeneration status, biodiversity indices and soil carbon in forest areas. Along with the assessment of trees outside forests in rural and urban areas, assessments of the utilisation of wood and non-

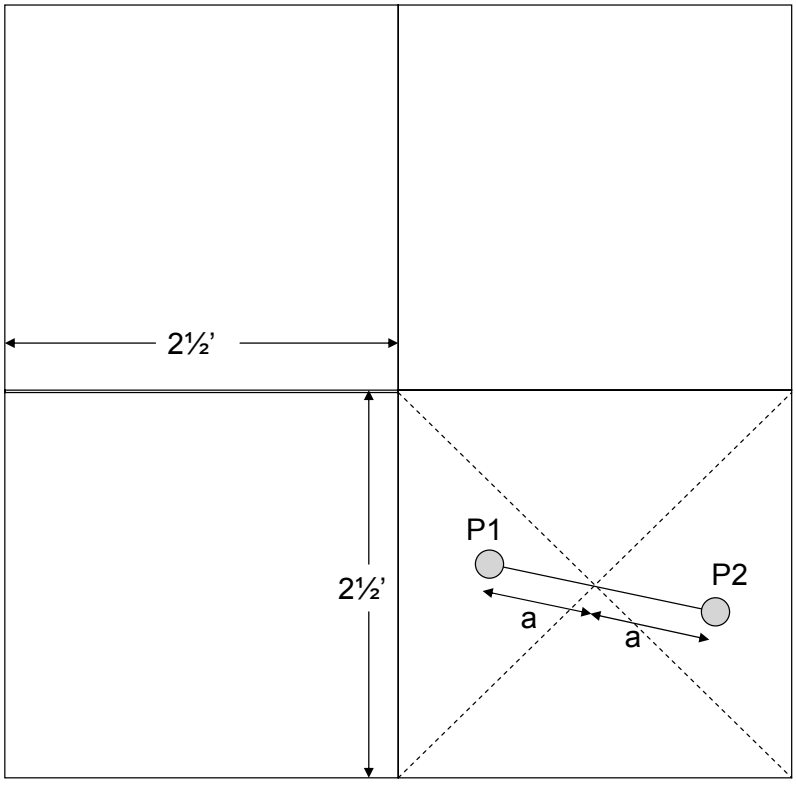

Figure 19.1 The sampling design for forest inventories (1965-1995) was systematic, with a grid size of 2.5' × 2.5' of latitude and longitude. Each grid cell contained 2 sample plots, each of 0.1 ha in size (31.62 × 31.62 m). The location of the first plot inside the grid cell is selected at random and the second is linked to it, being located at the same distance from the cell centre in the opposite direction.

wood forest products will be carried out through a household survey. Field data will be collected from sample plots based on stratification of the country into physiographic zones, each covering several states, and the drawing of a sample of 5% districts every year for a detailed inventory. Measurement of the field sample plots in selected districts will be entrusted to the zone offices in Bangalore, Kolkata, Nagpur and Shimla). The plots will be allocated by reference to the topographic map sheets (1:50 000), each map being divided into a grid of 144 elements representing 1 ¼' × 1 ¼' of latitude and longitude, and two cells of 2 ½' × 2 ½' selected at random from these, after which every second cell was systematically selected to form a sample sub-grid. One sample point will be marked at the centre of each of these cells. Thus two sample points are allocated to the centres of the cells of a small grid within one cell of the large grid. The plots include main plots of size 0.1 ha, four small "soil, forest floor and carbon" plots in the corners and four plant biodiversity

plots (3m × 3m and 1m × 1m) located about 50 m away on the diagonals of the main plot. This new design has been tested in pilot inventories in Bangalore, and time studies were carried out as well

The field data are currently collected using nine forms, the content of which can be described as follows:

1) Plot approach form, containing information on team composition, time required to reach the plot and timing of the measurements,
2) Plot description form, containing plot-level descriptions of general soil, crop and bamboo characteristics. The data are collected from 0.1 ha plots (31.62 m x 31.62 m).
3) Plot enumeration form, on which the species and diameters of all trees are listed,
4) Sample tree form, on which additional measurements made on the sample trees are recorded (dominance, dbh, height, crown width),
5) Bamboo enumeration by clumps form, on which the quantities of bamboo are enumerated by quality and diameter classes and by species,
6) Bamboo enumeration form for non-clumping culms, on which the quantities of bamboo are enumerated by quality and diameter classes and by species,
7) Bamboo weight form, which contains more detailed data on the sample bamboo stands by species (diameter, length, utilizable length, weight)
8) Herbs, shrubs and regeneration form, which contains data on the herb plots (1 m × 1m) and shrub and regeneration plots (3 m × 3 m). Species and collar diameter are recorded.
9) Soil and Forest Floor Carbon form, which contains data on gravel/soil and the weight by volume of the forest floor.

Some basic GPS models have been procured and will be used for navigation to the field sample plots. The FSI has around 40 field teams engaged on the field inventory work at present, each led by an FSI official, the rest of the team being hired on a contractual basis. The work would require the formation of around 75 teams, however. The field season is about 8-10 months, depending on the rains. About 2000 forest plots and their associated vegetation survey plots are currently measured each year. The data are also checked on a regular basis after collection, especially if the figures appear to be illogical. The data are stored mainly at Dehradun, where the volume characteristics etc. are also calculated on the basis of local models developed by the FSI, state departments and the FRI.

19.1.3 Trees outside the forest (TOF) and the household survey

TOF and household surveys are performed in parallel, and it was these that constituted the main activity of the inventory unit between 1991 and 2001. The methodology used at that time was based on conventional means of assessing TOF. Altogether 180 districts (out of the total of 593) were covered by the traditional method. Trees in about 2000 villages were enumerated, and related household surveys were carried out. More recently, a new sampling methodology has been tested in pilot areas, where outlines for the sample size and the shape and size of the plots were determined. Studies for stratification of the tree cover in rural areas into block, linear and scattered shapes have been carried out separately. Plot sizes may differ between strata. A new comprehensive assessment of tree resources outside the forest area will follow the procedure listed here:

1. Stratification of the country's geographical area into physiographic zones,
2. Selection of 10% of the districts every two years,
3. Delineation of the forest area and non-forest area in each district,
4. Use of remote sensing techniques for stratification of the forest and non-forest areas,
5. Generation of separate estimates for rural and urban non-forest areas,
6. Use of LISS III and PAN data,
7. Geometric correction,
8. Digital interpretation of satellite image data,
9. Overlaying of digitised forest boundaries on the classified imagery wherever available – to provide the TOF area,
10. Use of the fused LISS III and PAN data to give the TOF stratification,
11. Further division of the rural areas into three strata, block, linear and scattered, using the remote sensing images,
12. Use of sampling units as the sampling frame in the national urban statistics, and
13. Selection of the optimum number of sampling units in each district for the survey.

Household and wood consumption assessment is a separate exercise. A demand exists for data of this type, even though these surveys are very time-consuming. The following procedure will be used in the household surveys:

1. Household surveys will be conducted in rural and urban areas in selected districts.
2. Working Plans or utilization practices will be sought for local NWFPs, to provide the basis for preparing a schedule for NWFP utilization and consumption. The tradition of NWFP utilization and its timing can vary between areas.

3. The blocks of the national urban survey framework will be used in urban areas.
4. A list of households will be prepared.
5. Different classes of household will be indicated on this list.
6. 12 households will be selected within three pre-defined strata after a random start.
7. Ten villages adjacent to the peripheral plots of forest will be selected systematically in each rural area.
8. Ten villages will be selected at random from among the remaining ones.
9. Households will be selected as in the case of the urban areas.
10. The data will be recorded according to a prepared schedule.
11. In addition to consumption data, the report will also include sources of NWFPs
    a. From the market
    b. From the forests
    c. From collections

19.1.4 Forest management planning

The planning and management of forests forms an integral part of environmental planning. GIS technology is being put to use by several State Forest Departments (SFD) in order to prepare management plans within their administrative domains. The key areas in which GIS technology is being employed are (1) demarcation of environmentally degraded areas, including potential ones, and (2) developing models for locating centres of viable economic activity in order to ease pressure on the environment. Some SFDs are very advanced in this respect but others need further assistance and training. The FSI has provided expertise and training for several State Forest Departments in the use of Remote Sensing and GIS for the preparation of working plans.

A project for the assessment of TOF approved by the Forest Department, for example, involves estimation of the growing stock and the numbers of trees by species and diameter class located outside forests. Remote sensing techniques will be used to stratify the area concerned into three geometrical formations, i.e. linear, scattered and block plantations, after which field data will be collected and analysed. The project is expected to be completed within 18 months. The PAN data from IRS satellites 1C and 1D to be used in this project will be provided by the Forest Department itself.

19.2 INDONESIA

Indonesia's tropical forests are among the richest in the world. Some 75% of the country is covered by natural forests (about 143 million hectares), half of it "production forest". The coverage of natural forest is decreasing very rapidly, however, due to poor concession management, illegal logging, forest fires and land use conversion (e.g. to agriculture).

The government owns all the land in Indonesia and grants concessions to companies, local people manage the land in many areas as if it were their own, and thus the forestry companies are obliged to co-operate with them. Processed wood products generate up to 18% of the national income from exports. An urgent need exists for data on the actual extent of the forests, their biophysical characteristics, the process of deforestation and land cover change, and data are also needed for the verification of sustainable forest management and the surveillance of forest reserves. The Indonesian government has been working on an inventory of forests since 1989, using a combination of aerial photography and ground checks. The acquisition of useful information has often been prevented by cloud, fog and rain, however.

The Indonesian forests can be divided into natural forests and tree plantations, the latter covering 9.9 million ha, (3.5 million ha rubber, 1.5 million ha teak, and 3.9 million ha other broadleaved trees, including 1.1 million ha of industrial pulpwood plantations). Through the Ministry of Forestry, the Indonesian government and the Association of Forest Concession Holders are working together to develop systems for managing the Indonesian tropical rain forests. These bodies have the authority to define accepted systems and regulations governing forestry mapping and inventories of forest estates.

Information on Indonesian forestry is collected at three levels:

1. National level, based on maps on a scale of 1:2,500,000 covering the whole of Indonesia.
2. Provincial level, based on maps to a scale of 1:250,000.
3. Concession holder level, based on larger-scale maps, typically 1:25,000., The system provides information for each concession on forest cover types and contours, a digital elevation model, a five-year logging plan, a yearly logging plan, timber volumes, commercial species, replanting, etc.

19.2.1 The National Forest Inventory

The National Forest Inventory Project conducted by the government of Indonesia since 1989 (Revilla and Liang 1989, Sutter 1990a) has involved the use of remote sensing technologies coupled with a Digital Image Analysis System (DIAS) and a Geographic Information System (GIS) integrated with a Field Data Processing System (FDPS). This represents the first extensive inventory of forest resources (trees, rattan, bamboo, nipa and sagu) in Indonesia and, in view of the relatively high access cost involved, it was designed to collect as much field sample data as possible. The field data include details collected from permanent sample plots (PSP)

and temporary sample plots (TSP) which are to be used for forest status and change assessment at the national and province levels, respectively. Landsat MSS and TM images were used in combination with field data to produce the map presentations, however.

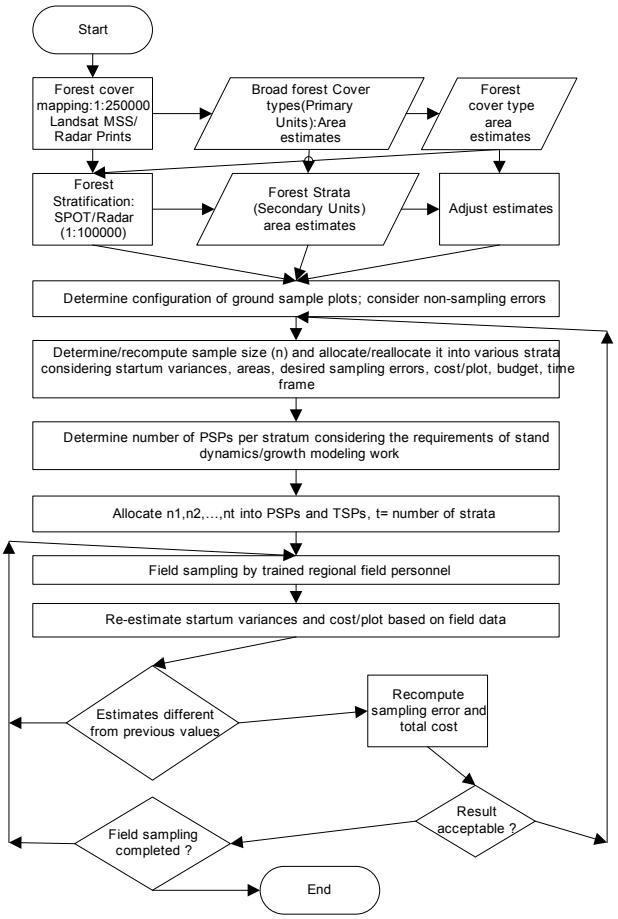

Figure 19.2 The NFI Sampling Design Process in Indonesia (3-stage sampling) (Revilla and Liang 1989, Sutter 1990a).

The plot clusters (Figure 19.3), distributed systematically with a random start, are arranged in a 20 × 20 km grid cell. All legal forest lands, as indicated on the Forest Land Use Planning Maps, are covered regardless of vegetation type. This includes all production forests, plantation forests and forests at higher altitudes, and protection and conservation forests at altitudes greater than 1,000 metres. There are about 3,300 plot clusters distributed throughout the country, except for the island of Java.

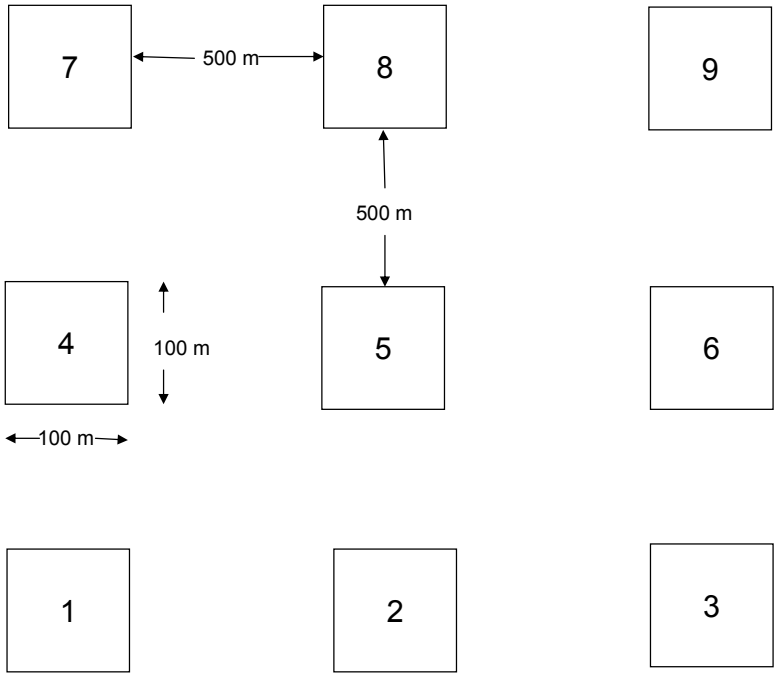

Figure 19.3 Plot cluster layout used in the Indonesian NFI. Each TSP contains 9 tracts and each PSP is a 1 ha plot (Revilla and Liang 1989, Sutter 1990a, Sutter 1990b).

19.2.2 Concession renewal mapping

The Indonesian Association of Forest Concession Holders has set up a company (PT MAPINDO PARAMA) to monitor forest exploitation and conversion, whether to agriculture, settlement, or replanting. The company monitors a total of 85 million hectares, and its concessions, which are awarded for 20 years, are divided into 35 lots. A concession entitles the holder to exploit one lot per year. Most of the timber companies are forced to use this company's products.

Any company seeking renewal of its concession must demonstrate compliance with the logging regulations during the previous concession period. As it is designed to fulfil a range of needs, the forest resource information system developed by MAPINDO manages data from several sources, including:

1. Aerial photographs to a scale of 1:20,000, used to assess forest cover types and commercial timber volumes. The survey takes five years to complete and will be repeated every five years. Aerial photos are also used to compile contour and vegetation maps to a scale of 1:25,000, and are combined with field survey data to classify forests on the basis of type,

crown density, stand height and crown diameter.

2. Synthetic aperture radar (SAR) imagery. A pilot study using airborne SAR supplemented with GPS position data was undertaken in the mountainous parts of Kalimantan. Oblique SAR is capable of acquiring images with a resolution of 6 metres irrespective of cloud cover. This one-year study will result in topographic contour and thematic maps covering much of central and eastern Kalimantan.
3. Satellite imagery is being used for the annual monitoring of forest exploitation. The images are used to produce a general classification by forest type and to identify the areas to be left as primary forest or to be exploited as forest estates.

19.2.3 Forest management planning: compartment-level inventories of natural forests

The silvicultural system known as Indonesian Selective Cutting and Planting comprises logging practices with a diameter limit and forest regeneration. This was initially referred to in 1972 as Indonesian Selective Cutting (TPTI). It is a series of planned forest management activities which include logging, regeneration and tending of the forest stands in order to ensure the sustainability of timber or other forest production. To achieve the expected target, the following series of activities and schedules have been established for each harvesting area:

Stage of TPTI Activities	Time of Implementation (year) (Et = time of harvesting operation)
Organization of working area	Et – 3
Stand inventory before logging	Et – 2
Opening up of forest area	Et- 1
Logging	Et
Liberation	Et+ 1
Inventory of residual stand	Et+ 1
Procurement of planting stock	Et + 2.
Enrichment planting	Et + 2
First-stage tending	Et + 3
Advanced tending	
a. Liberation	Et + 4
b. Thinning	Et + 9
	Et+ 14
	Et+ 19
Forest protection and research	Continually

The annual logging units have traditionally been 1 km × 1 km blocks, and the present regulations recommend natural borders for the delineation of these units. Timber companies are keen to find locations with a high volume of valuable trees, and thus they usually use aerial photos to locate the forests with the highest

potential. The dense crown cover makes the interpretation of single trees difficult, however, and it is also difficult to identify species from a bird's eye view. (The identification of trees is even difficult from the ground.).

According to the TPTI rules, a stand inventory (Pre-felling inventory, cruising) has to be carried out one year before harvesting, in order to determine the volume of trees over 50 cm in diameter to be harvested. For this purpose the logging unit is tallied in detail, tree by tree, and individual trees are located within the square area (all trees over 50 cm). These tree location maps must be submitted with the application for a logging license.

An inventory of the residual stand (after-felling inventory) has to be made in all forest areas two years after logging, to check the condition of the forest stand at that stage. This differs from the pre-felling inventory in that all trees over 20 cm in diameter are measured and regeneration is estimated by sampling. Tree location maps are produced to control the logging intensity.

19.2.4 Forest management planning: compartment-level inventories of plantation forests

The most important plantation organization is Perum Perhutani, the state-owned forestry company, which has 1.36 million hectares of plantations, mostly of teak (within a total of 3 million hectares of forest). The management method, called Clear Cutting with Artificial Regeneration (THPB), has been practised in Java since 1880. The tree species most frequently planted up to now consist of indigenous or exotic species, the most common exotic species are *Acacia mangium, Acacia crassicarpa, Acacia auriculiformis, Gmelina arborea and Eucalyptus urophylla.*

Figure 19.4 A typical sample of a young Acacia mangium plantation.

The THPB silvicultural system can be used for establishing a plantation

forest either for land rehabilitation or for the industrial production of fast growing species (HTI). An example of its implementation is the conversion of natural forest into plantation forest, e.g. the conversion of non-teak forest in Java into pine forest, agathis forest etc. Other examples are the establishment of mangrove forests, the establishment of plantation forests along the coast and the reforestation of alang-alang (Imperata cylindrica) fields outside Java. In practice, the THPB method is very close to Scandinavian stand-bsed forest management system.

Since the value of the plantation forests is an object of interest for the financing institutions (banks), supporting agencies (Indonesian government bodies) and timber/paper companies, inventory methods are developing rapidly in this sector and the companies are constantly open to innovations.

Private forest estates have started to use orthophotographs and EnsoMosaic products (Figure 19.4) in their forest plantation information systems. The resulting images are used to plan fieldwork and to control the quality of wood resources. Mostly paper prints are used to digitize the delineation of stands, which are classified according to planting year and species. Tree attribute information is collected from subjectively located field sample plots by means of specific tallysheet, relascope and height estimation tools. Companies store the inventory data mostly in GIS data layers.

19.3 CHINA

China conducted 4 national forest resource inventories in the period 1973-1993. The results achieved in the Fourth National Forest Resource Inventory (1989-1993) revealed that the land area used for forestry purposes is 262.89 million ha, with a forest area totalling 133.7 million ha and a forest cover of 13.92%, an increase of 8.03 million ha compared with the results of the Third National Forest Resource Inventory (1984-1988). Likewise, the plantation area had increased by 2.78 million ha, from the previous figure of 31.01 million ha to 33.79 million ha, representing an average annual increment of 650,000 ha.

The huge flood problems experienced in China in summer 1998 caused the government to impose a total logging ban in order to preserve the natural drainage basins. Since that time local foresters in the natural forest sector have been mainly responsible for forest planning and design, the planting trees and research, while plantation forestry has started to grow in southern China as foreign investors (e.g. all the most important paper manufacturers) have entered the country.

Aerial photography was introduced in 1954. It was first used to delineate the boundaries of stands and working units such as compartments and sub-compartments, and then to deduce forest types, tree species, site indices, stand volumes and other stand variables. Angle count sampling was introduced in 1957 to improve on the ocular estimation technique, and stratified sampling was first tried in 1963. Since then, the forest inventory technique has progressively moved over from ocular estimation to statistical sampling. Meanwhile, research and experimentation has been focused on inventory methods that would be suitable for different areas, conditions and management levels, such as two-stage and multistage sampling

inventories, double sampling with regression, and regression based surveys with visual estimation and field mensuration, etc. Most of these methods have already been put into practice.

In order to monitor the dynamic changes taking place in national forest resources, a CFI (continuous forest inventory) system has been set up in all the provinces with permanent sampling plots. There are 250,000 permanent sampling plots in the whole country. 15 provinces have been remeasured since 1986, and satisfactory results have been achieved.

Remote sensing data have been used for forest mapping and monitoring in China for more than 40 years. Foresters used only aerial photographs for inventory purposes between 1950 and 1970, but use has also been made of satellite remote sensing data since 1980, although mostly in development projects rather than everyday operations.

19.3.1 National Forest Inventory: natural forests

The area of China is covered by a permanent field sample plot network which is planned to be measured in 5-year periods. The sample plots are in general 20×30 m^2 in size and located in 2 km $\times$ 4 km grid cells. There are a total of about 230 000 sample plots over the whole country. Altogether 35 variables are measured on each plot, and the data are stored in a Dbase database. The NFI results are calculated using field samples for administrative units.

19.3.2 Forest management planning: compartment-level inventories

A province in the Chinese forest management planning system includes several forestry bureaus. each divided into several forest farms (e.g. one sample forestry bureau includes 12 forest farms). Each forest farm comprises several compartments as its administration units, and these compartments are then divided into sub-compartments according to their silvicultural condition. In terms of Finnish forestry, the Chinese forest compartments correspond primarily to forest farms and the sub-compartments to forest stands, but the management areas or treatment units are usually more extensive in China.

Data from the stand inventories are recorded in a forest register, which includes stand information such as area, species, age, volume, growth and degree of stocking by sub-compartments. The forest registers are then summed to apply to larger management units. The accuracy of this compilation method depends on the stand inventory techniques employed, e.g. aerial photography, visual estimation, sampling techniques and yield tables. The number of sample points ranges between 3 and 14 depending on the size of the sub-compartments. The compilation method has now beeen taken into use and supplemented with stratification based on aerial photographs or satellite images.

19.4 OTHER ASIAN AREAS

Industrial plantation forest inventories are very similar in all the Asian countries

(and actually world-wide), since the rotation time is short and investment relatively high (so that intensive inventories are acceptable). Thus aerial photographs are commonly used in conjunction with field sampling .

Remote sensing is also particularly useful for extensive or distant areas of forest where access is difficult, and these techniques, including aerial photography, are arousing much interest in connection with the tropical forests of south Asia in particular. Aerial photographs provide us with certain strata, such as forest types, density classes and height classes, and it is possible in some cases to identify certain tree species and to assess the volume of their growing stock. Most countries began to use aerial photographs as a means of stratifying forest lands when carrying out a national forest inventory after the Second World War, and then as the tool for forest planning and management.

The following paragraphs briefly describe the use of remote sensing data in selected Asian countries:

Japan

There are a great number of pure plantations, totalling 10 million ha, so that stratification techniques are very useful for reducing internal variance smaller and applying various models for the assessment of actual forests (Minowa 1992).

Taiwan

The national forest inventory employs aerial photography in its primary sampling. Approximately 134,000 photo points were selected over the entire island, after which field locations were selected at an density of one per 900 hectares, which resulted in 4,132 locations (2,491 in forests) for the entire island (Minowa 1992).

Korea

The fourth national forest inventory was conducted between 1986 and 1990 (the first one in 1962-1964). To reduce the number of field plots, cost and time, a stratified double sampling technique was adopted with the combined use of aerial photographs and ground surveys.

Forest lands were classified into several types using B&W aerial photographs on a scale of 1: 15000. The number of sampling plots was determined statistically in order to be able to estimate the total growing stock with a relative precision of 5% at the 95% confidence level (Minowa 1992).

Philippines

The national forest inventory employs a two-stage sampling approach using small scale aerial photographs (1:60,000) and Landsat false colour composites (FCC) as the area frame and relascope samples as the ground truth information. A two-stage design was introduced in 1983 that concentrated the field sampling in selected forest strata. In order to keep the standard error below 3%, a total of 2,000 field clusters are required. These clusters are allocated to the regions and provinces in proportion to their forest cover (Minowa 1992).

Malaysia

Inventory methods in Malaysia have traditionally been very similar to those in Indonesia, and the Malysian natural forest management system is very similar to the Indonesian TPTI system (Minowa 1992).

Thailand

Remote sensing has been used by the Royal Forest Department as a useful technique for national forest inventory purposes. Landsat images in particular can reduce the time and personnel needed for assessing the existing forest area over the entire country, as a survey can be completed in only one year as compared with ten years when conventional aerial photographs are used (Minowa 1992).

Aerial photography was first applied to forestry in 1955, for the delineation of various forest types and the compilation of forest maps. The Thailand National Remote Sensing Programme was established in 1972. At present, aerial photographs and Landsat images are being used to compile maps of forest types, forest land use, vegetation cover and existing forests. Landsat images cannot be used for the classification of all forest types, however, and consequently both aerial photographs and Landsat data are used in the national forest inventory.

Interpretationa made in the office by trained staff are verified by means of ground surveys.

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